Circular Motion

2008

A4. A bend on a smooth racing track forms an arc of a circle of radius r metres. The track is banked at an angle α to the horizontal. A car takes the bend at speed $v\ \text{m s}^{-1}$ with no tendency to move either up or down the track.

Express v in terms of α, r and g. **3**

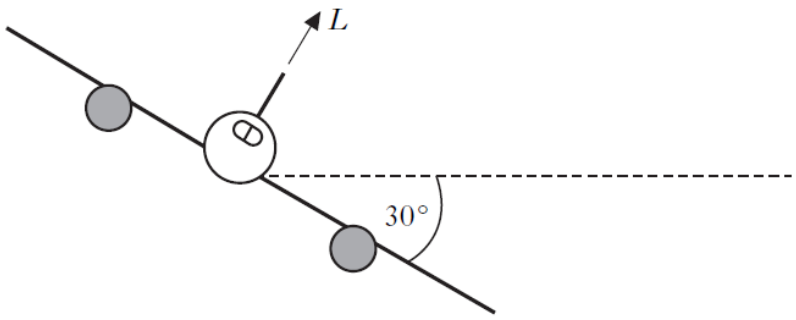
2009

A8. The bend on a racetrack is semi-circular with radius r metres and is banked at 45 ° to the horizontal. A cyclist takes the bend with speed $\sqrt{3gr}\ \text{m s}^{-1}$ and is on the point of sliding **up** the banked track.

Calculate the coefficient of friction between the cycle wheels and the surface of the racetrack. **6**

2011

A3. An aircraft flies at constant speed U metres per second in a horizontal circular orbit of radius R metres.



The wings of the aircraft are banked at 30° to the horizontal and generate a lift force of L newtons. This force acts perpendicular to the wing surface, as shown in the diagram.

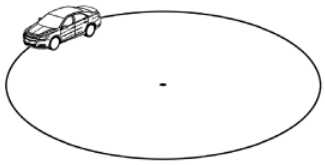
Show that the radius of the circular orbit is given by

$$R = \frac{\sqrt{3}U^2}{g}.$$ **4**

Hence find an expression for the orbital period in terms of U and g. **2**

2012

A1. A car travels at a uniform speed of $80\ \text{km h}^{-1}$ on a horizontal circular track of radius 150 metres without slipping. Calculate the coefficient of friction between the tyres and the track. **3**



2016 SP

17. A car of mass Mkg is travelling with a speed of $v\,\text{m s}^{-1}$ round a circular bend of radius 40 metres on a road banked at 30° to the horizontal. The coefficient of friction between the car tyres and the road surface is μ.

(a) Show that the square of the maximum speed the car can travel without slipping is given by

$$v^2 = \frac{392(1+\sqrt{3}\mu)}{\sqrt{3}-\mu}$$

5

The minimum speed that the car can travel round the bend without slipping is $u\,\text{m s}^{-1}$.

(b) Given that $v = 3u$, calculate the coefficient of friction between the car tyres and the road. **6**

2016

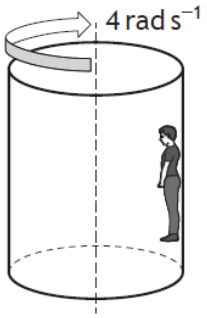
9. A velodrome has a circular track of radius 30 metres, banked at an angle of 32° to the horizontal. The coefficient of friction between a bicycle tyre and the track is 0·3.

(a) Once the cyclist reaches maximum speed without the bicycle slipping, he cycles for 5 minutes. Assuming he maintains this speed, how many full laps does he complete? **6**

(b) Given that air resistance can be ignored and the cyclist is treated as a particle, what other assumption has been made? **1**

2017

6. A ride at an amusement park consists of a hollow cylinder of radius 3·5 metres which rotates about its vertical axis of symmetry.



When the angular speed reaches $4\,\text{rad s}^{-1}$ the floor is lowered and a person remains in contact with the inner surface of the cylinder without slipping.

What is the minimum coefficient of friction to prevent the person from slipping? **4**

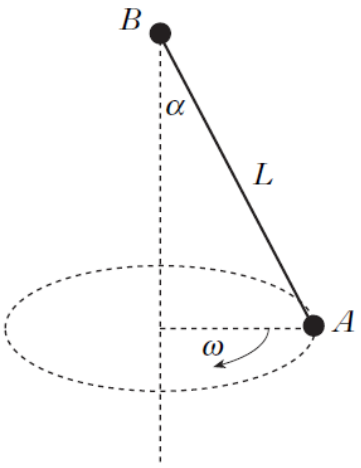
Conical Pendulums

2005 SP

6. (*a*) A particle of mass m kilograms is attached by a light inextensible string to a fixed point O. The particle moves in a horizontal circle whose centre is a distance h metres vertically below O. Derive an expression for h in terms of ω and g, where ω is the angular speed of the particle and g is the magnitude of the acceleration due to gravity. **4**

2005

A6. A ball of mass m kg is attached to one end A of a light inextensible string of length L metres. The other end of the string is attached to a fixed point B. The ball moves, with string taut, in a horizontal circle with constant angular speed ω radians per second as shown in the diagram. During this motion, the string is inclined at an angle α to the downward vertical through B where $\tan\alpha = \frac{5}{12}$.

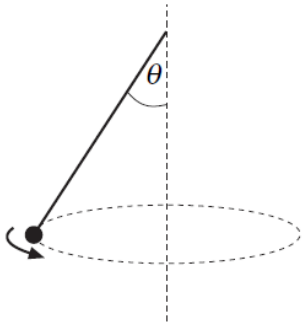


(*a*) Find the tension in the string in terms of m and g. **2**

(*b*) Find an expression for ω in terms of g and L. **3**

2010

A2.



A particle of mass 2 kg is attached to one end of a light inextensible string of length 2 metres. The other end of the string is held fixed while the mass moves in a horizontal circle about a vertical axis at 5 radians per second.

Calculate the size of angle θ, between the string and the vertical axis. **5**

2014

A4. Two light inextensible strings each have one end attached to a particle P of mass 2 kg. The other ends of the strings are attached to fixed points A and B where A is vertically above B.

The particle moves with a constant speed in a horizontal circle whose centre is 30 cm below B. When the strings are inclined at 30° and 50° to the vertical, both strings are taut with the tension in AP twice that in BP.

Find the linear speed of the particle. **6**